BASIC
CLINICAL NUTRITION

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19 กรกฎาคม 2555
OUTLINE

- Nutritional Screening, Assessment, and Monitoring
- Malnutrition
  - Under-nutrition
  - Over-nutrition
- Nutritional support
  - General approach and complications
  - Enteral Nutrition (EN)
  - Parenteral Nutrition (PN)
- Conclusions
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  - Under-nutrition \(\rightarrow\) PEM
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  - Enteral Nutrition (EN)
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- Conclusions
Algorithm for Delivery of Nutrition Support

- **Nutrition Screen**
  - Risk or Presence of Malnutrition??
  - **Not-at-Risk**
  - **At-Risk or Malnourished**
    - Rescreen at:
      - Regularly specified intervals or
      - When nutritional/clinical status changes
    - Nutrition Assessment
    - Develop Nutrition Care Plan
    - Reassessment

Nutrition Support Teams (NSTs)

- Typically, NSTs consist of a physician, dietitian, nurse, and pharmacist
- Potential benefits of a NST
  - Decreases complications: septic, metabolic, mechanical (catheter-related), drug-nutrient interactions
  - Cost-effective
  - Research and education
  - Improved patient care, nutritional status, and other outcomes
Algorithm for Delivery of Nutrition Support

Nutrition Screen

Risk or Presence of Malnutrition??

Not-at-Risk

At-Risk or Malnourished

Rescreen at:
• Regularly specified intervals or
• When nutritional/clinical status changes

Nutrition Assessment

Develop Nutrition Care Plan

Reassessment

Nutritional Screening

- Nutritional screening essentially **gathers information** on risk or presence of malnutrition

- **Subjective** parameters

- To evaluate whether a nutritional assessment is required to determine if a patient is malnourished or at risk for malnutrition

- **JCAHO 2005**: within 24 hours of hospital admission
Nutritional Screening tool

- Simple
- Easy to complete
- Inclusive of routine data readily available
- High sensitivity
- Cost-effective
- Reliable and valid
- Clinically relevant
- Age-appropriate
- e.g. SGA, MUST for adults, NRS 2002, etc.
Nutritionally-at-Risk

- Involuntary loss or gain of >10% of usual BW within 6 months or >5% of usual BW in 1 month, or a weight of ≥ or ≤ 20% of ideal BW
- Presence of chronic disease, or increased metabolic requirements
- Altered diets or diet schedules (receiving parenteral or enteral nutrition, recent surgery, illness)
- Inadequate nutrition intake > 7 days

Adapted from ASPEN 2007.
Screening: 4 Common Basic Questions

- Recent weight loss
- Recent food intake
- Current BMI
- Disease severity or other measure of predicting risk of malnutrition
# Weight Loss Significance

<table>
<thead>
<tr>
<th>Length of time</th>
<th>Significant (%)</th>
<th>Severe (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 wk</td>
<td>1-2</td>
<td>&gt; 2</td>
</tr>
<tr>
<td>2-3 wks</td>
<td>2-3</td>
<td>&gt; 3</td>
</tr>
<tr>
<td>1 mo</td>
<td>4-5</td>
<td>&gt; 5</td>
</tr>
<tr>
<td>3 mos</td>
<td>7-8</td>
<td>&gt; 8</td>
</tr>
<tr>
<td>5+ mos</td>
<td>10</td>
<td>&gt; 10</td>
</tr>
</tbody>
</table>

SGA

(Subjective Global Assessment)
Magnitude of *weight loss* and reduced *appetite* are the best criteria for predicting SGA score in adult patients.

MUST for adults

**BMI score**
- > 20 = 0
- 18.5-20 = 1
- < 18.5 = 2

**Wt loss score**
- < 5% = 0
- 5-10% = 1
- > 10% = 2

**Acute disease effect score**
+2 if there has been or is likely to be no nutritional intake for > 5 days

---

**Overall risk of malnutrition and management guidelines**

- 0 = Low risk → Routine clinical care
- 1 = Medium risk → Observe
- ≥ 2 = High risk → Treat

**MUST – The Malnutrition Universal Screening Tool**

NRS (Nutritional Risk Screening) 2002
<table>
<thead>
<tr>
<th>Impaired nutritional status</th>
<th>Severity of disease (≈ requirement/stress-metabolism)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mild</strong></td>
<td>Hip fracture (9). Chronic patients, in particular with acute complications: cirrhosis (11), COPD (12). <em>Chronic hemodialysis, diabetes, malignant oncology.</em></td>
</tr>
<tr>
<td>Score 1</td>
<td>Score 1</td>
</tr>
<tr>
<td>Food intake &lt;50-75% of normal requirement in preceding week</td>
<td>Score 2</td>
</tr>
<tr>
<td><strong>Moderate</strong></td>
<td></td>
</tr>
<tr>
<td>Score 2</td>
<td></td>
</tr>
<tr>
<td>Wt loss &gt;5% in 2 mths Or</td>
<td>Head injury (18, 19). Bone marrow transplantation (20). <em>Intensive care patients (APACHE &gt;10).</em></td>
</tr>
<tr>
<td>BMI 18.5 - 20.5 + impaired general condition Or</td>
<td>Score 3</td>
</tr>
<tr>
<td>Food intake 25-50% of normal requirement in preceding week</td>
<td></td>
</tr>
<tr>
<td><strong>Severe</strong></td>
<td></td>
</tr>
<tr>
<td>Score 3</td>
<td></td>
</tr>
<tr>
<td>Wt loss &gt;5% in 1 mth (≈ &gt;15% in 3 mths (17)) Or</td>
<td></td>
</tr>
<tr>
<td>BMI &lt;18.5 + impaired general condition (17) Or</td>
<td></td>
</tr>
<tr>
<td>Food intake 0-25% of normal requirement in preceding week</td>
<td></td>
</tr>
</tbody>
</table>

Score: + Score: = TOTAL SCORE:
Algorithm for Delivery of Nutrition Support

**Nutrition Screen**

Risk or Presence of Malnutrition??

- **Not-at-Risk**
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    - Regularly specified intervals or
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- **At-Risk or Malnourished**
  - Nutrition Assessment
    - Develop Nutrition Care Plan
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Nutritional Assessment

- Review of nutrition history
- Review of clinical status
- Nutritionally focused physical examination
- Evaluation of anthropometric data
- Biochemical indices of nutrition status
Nutritional Assessment

1. Assessment of nutritional status
2. Medical problem(s)/disease(s)
3. Energy, macro/micronutrient and fluid requirements
4. Follow up
Nutritional Assessment

- Review of **Nutrition History**
- Review of **Clinical Status**
- Nutritionally focused physical examination
- Evaluation of anthropometric data
- Biochemical indices of nutrition status
History

- To identify **underlying mechanism** that put the patients at risk for nutritional depletion (or excess)
  - Inadequate intake
  - Impaired absorption
  - Decreased utilization
  - Increased losses
  - Increased requirements of nutrients
- 24-hour **dietary recall** → Dietitian
<table>
<thead>
<tr>
<th>Mechanism of Deficiency</th>
<th>History</th>
<th>Deficiencies to suspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate intake</td>
<td>Alcoholism</td>
<td>Calories, protein, thiamine, niacin, folate, pyridoxine, riboflavin</td>
</tr>
<tr>
<td></td>
<td>Avoidance of meat, dairy products, eggs</td>
<td>Protein, B$_{12}$</td>
</tr>
<tr>
<td></td>
<td>Isolation, poverty, dental disease</td>
<td>Various nutrients</td>
</tr>
<tr>
<td></td>
<td>Weight loss</td>
<td>Calories, other nutrients</td>
</tr>
<tr>
<td>Inadequate absorption</td>
<td>Malabsorption (diarrhea, weight loss, steatorrhea)</td>
<td>Calories, protein, thiamine, niacin, folate, pyridoxine, riboflavin</td>
</tr>
<tr>
<td></td>
<td>GI surgery</td>
<td>B$_{12}$, iron, folate</td>
</tr>
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<td>History</td>
<td>Deficiencies to suspect</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Decrease utilization</td>
<td>Inborn errors of metabolism</td>
<td>Various nutrients</td>
</tr>
<tr>
<td>Increased losses</td>
<td>Alcohol abuse</td>
<td>Mg, Zn</td>
</tr>
<tr>
<td></td>
<td>Blood loss</td>
<td>Iron</td>
</tr>
<tr>
<td></td>
<td>Centesis</td>
<td>Protein</td>
</tr>
<tr>
<td></td>
<td>Uncontrolled DM</td>
<td>Calories</td>
</tr>
<tr>
<td></td>
<td>Diarrhea</td>
<td>Protein, Zn, electrolytes</td>
</tr>
<tr>
<td></td>
<td>Draining abscess, wounds, nephrotic syndrome</td>
<td>Protein, Zn</td>
</tr>
<tr>
<td></td>
<td>PD or HD</td>
<td>Protein, Zn, water, soluble vitamins</td>
</tr>
<tr>
<td>Increased requirements</td>
<td>Fever, hyperthyroidism</td>
<td>Calories</td>
</tr>
<tr>
<td></td>
<td>Surgery, trauma, burns, infection</td>
<td>Calories, protein, vitamin C, Zn</td>
</tr>
</tbody>
</table>
Nutritional Assessment

- Review of nutrition history
- Review of clinical status
- **Nutritionally Focused Physical Examination**
- Evaluation of anthropometric data
- Biochemical indices of nutrition status
Specific Physical examination

- Skin
- Nails
- Hair
- Mouth, teeth, and gum (including difficulty chewing or swallowing)
Malnutrition

- Includes any nutritional alteration:
  - Undernutrition (deficiency illnesses)
  - Overnutrition (overweight and obesity)

- PEM can be the result of:
  - Chronic starvation
    (HYPOmetabolism) \(\rightarrow\) “Marasmus”
  - Acute, stress-related starvation
    (HYPERmetabolism) \(\rightarrow\) “Kwashiorkor”

PEM – Protein-energy malnutrition

AS PEN, 2005.
Marasmus
Kwashiorkor
Cellophane sign → Kwashiorkor
Perifollicular petechiae $\rightarrow$ Vitamin C deficiency
Follicular hyperkeratosis → Vitamin A +/- C deficiency
Easy hair pluckability → Kwashiorkor
Flag sign $\rightarrow$ Kwashiorkor
Flag sign → Kwashiorkor (resolved)
Nails

Mees’ lines

Beau’s lines
Atrophic lingual papillae = slick tongue
Angular stomatitis
Nutritional Assessment

- Review of nutrition history
- Review of clinical status
- Nutritionally focused physical examination
- Evaluation of **Anthropometric Data**
- Biochemical indices of nutrition status
Anthropometrics

- Body mass and fat reserves
- BW, height $\rightarrow$ BMI
- Triceps skinfold (TSF)
- Mid-arm muscle circumference (MAMC)
## BMI and Nutritional Status

<table>
<thead>
<tr>
<th>BMI (kg/m²)</th>
<th>Nutritional Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 30</td>
<td>Obese</td>
</tr>
<tr>
<td>25-30</td>
<td>Overweight</td>
</tr>
<tr>
<td>20-25</td>
<td>Normal</td>
</tr>
<tr>
<td>&lt; 18.5</td>
<td>Moderate malnutrition</td>
</tr>
<tr>
<td>&lt; 16</td>
<td>Severe malnutrition</td>
</tr>
<tr>
<td>&lt; 13</td>
<td>Lethal in males</td>
</tr>
<tr>
<td>&lt; 11</td>
<td>Lethal in Females</td>
</tr>
</tbody>
</table>

Driscoll D, and Bristian B. Parenteral and enteral nutrition in the intensive care unit, in Intensive Care Medicine, Irwin R, Rippe J (eds), 2003.
Nutritional Assessment

- Review of nutrition history
- Review of clinical status
- Nutritionally focused physical examination
- Evaluation of anthropometric data
- Biochemical Indices of Nutrition Status
## Laboratory Tests (1)

<table>
<thead>
<tr>
<th>Test</th>
<th>Nutritional Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum albumin (3.5-5.5 g/dL)</td>
<td>□ 2.8-3.5 → compromised protein status</td>
</tr>
<tr>
<td></td>
<td>□ &lt; 2.8 → Possible kwashiorkor</td>
</tr>
<tr>
<td>Serum prealbumin (20-40 mg/dL)</td>
<td>□ 10-15 → mild protein depletion</td>
</tr>
<tr>
<td></td>
<td>□ 5 - 10 → moderate protein depletion</td>
</tr>
<tr>
<td></td>
<td>□ &lt; 5 → severe protein depletion</td>
</tr>
<tr>
<td>Serum TIBC (240-450 μg/dL)</td>
<td>□ &lt; 200 → compromised protein status, possible kwashiorkor</td>
</tr>
<tr>
<td></td>
<td>□ More labile than serum albumin</td>
</tr>
</tbody>
</table>
## Laboratory Tests (2)

<table>
<thead>
<tr>
<th>Test (Normal values)</th>
<th>Nutritional Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prothrombin time (12-15.5 sec)</td>
<td>□ Prolongation → vitamin K deficiency</td>
</tr>
</tbody>
</table>
| Serum creatinine (0.6-1.6 mg/dL) | □ Reflects muscle mass  
□ < 0.6 → muscle wasting due to prolonged energy deficit |
| BUN (8-23 mg/dL) | □ < 8 → possibly inadequate protein intake  
□ 12-23 → possibly adequate protein intake  
□ > 23 → possibly excessive protein intake |
| 24-hr UUN | To be elaborated later |
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Time Course of PEM

- Severity of PEM:
  - Mild
  - Moderate
  - Severe

- Time:
  - Days
  - Weeks
  - Months
  - Years

- Conditions:
  - Kwashiorkor
  - Marasmus

- Stages:
  - Mildly catabolic
  - Severely catabolic
# Comparison of Marasmus and Kwashiorkor

<table>
<thead>
<tr>
<th></th>
<th>Marasmus</th>
<th>Kwashiorkor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clinical setting</strong></td>
<td>↓ Energy intake</td>
<td>↓ Protein intake during stress state</td>
</tr>
<tr>
<td><strong>Time course to develop</strong></td>
<td>Months to years</td>
<td>Weeks</td>
</tr>
<tr>
<td><strong>Clinical features</strong></td>
<td>• Starved appearance</td>
<td>• Well-nourished appearance</td>
</tr>
<tr>
<td></td>
<td>• Wt &lt; 80% standard for Ht</td>
<td>• Easy hair pluckability</td>
</tr>
<tr>
<td></td>
<td>• Triceps skinfold &lt;3 mm</td>
<td>• Edema</td>
</tr>
<tr>
<td></td>
<td>• MAMC &lt; 15 cm</td>
<td></td>
</tr>
<tr>
<td><strong>Laboratory findings</strong></td>
<td>Creatinine-height index &lt; 60% standard</td>
<td>• Serum alb &lt; 2.8 g/dL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• TIBC &lt; 200 μg/dL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• TLC &lt; 1500/μL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Anergy</td>
</tr>
</tbody>
</table>
## Comparison of Marasmus and Kwashiorkor

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<thead>
<tr>
<th>Clinical course</th>
<th>Marasmus</th>
<th>Kwashiorkor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reasonably preserved responsiveness to short-term stress</td>
<td>Infections</td>
<td>Poor wound healing, decubitus ulcers, skin breakdown</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mortality</th>
<th>Low unless related to underlying disease</th>
<th>High</th>
</tr>
</thead>
</table>

<table>
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<tr>
<th>Diagnostic criteria</th>
<th>Marasmus</th>
<th>Kwashiorkor</th>
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<td>• Triceps skinfold &lt; 3 mm</td>
<td>• Serum albumin &lt; 2.8 g/dL</td>
<td></td>
</tr>
<tr>
<td>• MAMC &lt; 15 cm</td>
<td>• At least ONE of the following:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1) poor wound healing, decubitus ulcers, or skin breakdown</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2) Easy hair pluckability</td>
<td></td>
</tr>
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Definition: Nutrition Support

- "Nutrition Support"¹
  : Orally modified formulas or intravenous nutrition necessitated by inability to consume a general diet; administered to malnourished individuals who cannot consume food in its original form.

- "Nutrition Therapy"²
  : A component of medical treatment that includes oral, enteral, and parenteral nutrition.

- "Nutrition Support Therapy"²
  : Parenteral and/or enteral nutrition.

Objectives of Nutritional Support

1. To support the patient **during** the systemic response in inflammation, injury, or infection during an extended critical illness

2. To provide adequate nutritional intake **during** the recovery phase of illness or injury

3. For patients with **permanent loss of intestinal length or function**
When to Use Nutritional Support???

: To increase the likelihood of

- Recovery
- Reduce infection rates
- Improve healing
- Shorten the hospital stay
Feeding Approaches

Oral

Oral

Peripheral vein

Peripheral vein

Enteral routes

Central vein

PICC

Parenteral routes

Central vein

Tube

PICC: Peripherally inserted central catheter

“If the gut works, use it”
Enteral and parenteral feeding routes

Percutaneous gastrojejunalostomy (PEG-J)
Advantages of Enteral Feeding over Parenteral feeding

- Physiologic superiority
- Maintenance of intestinal structure and function (immunological and barrier integrity)
- Protection against sepsis and MOF
- Lower cost
- Safety

*If the GI tract is not able to be used or is unreliable for > 5-7 days, PN should be used.*
Energy Requirements

- **Predictive equations**
  - less accurate especially in the obese patient
  - Harris-Benedict equations were developed in adults with roughly normal body weights

- **Indirect calorimetry**
  - is useful for
    - Hypermetabolic patients whose BW cannot be obtained accurately
    - Patients w/ difficulty weaning from a ventilator
    - Patients at the extremes of weight or age
Energy Requirements

Total 24-hour energy expenditure (TEE)
= BEE x (1.1 to 1.4)

- BEE = Basal energy expenditure

"Harris-Benedict equations":

- BEE ♂ = 66.47 + 13.75W + 5H - 6.76A
- BEE ♀ = 655.10 + 9.56W + 1.85H - 4.68A

W = Current weight (kg)
H = Height (cm)
A = Age (years)

** Use - “dry” weight for edematous patients and
- “adjusted” weight for patients w/ BMI ≥ 30

Energy Requirements

- **Rule of Thumb**
  - Stable hospitalized patients: 25-30 (30-35) Kcal/kg/day
  - Obese patients: 21 Kcal/kg/day
Estimating BEE in “Obese Patients”

Actual weight = \( \text{Actual weight} \)

Ideal weight = \( \text{Ideal weight} \) (IBW)

Adjusted weight = \( \text{Adjusted weight} \) (ABW)

\[ \text{Adjusted weight} = \text{Ideal weight} + \{50\% \times (\text{Actual weight} - \text{Ideal weight}) \} \]
Estimating BEE in “Obese Patients”

Adjusted body weight

= IBW + [ 0.5 x ( Actual BW-IBW )]

Where IBW is calculated as:

- **IBW ♂**
  = 106 lb (48 kg) for the first 5 ft (152 cm) of ht,  
  + 6 lb (2.7 kg) for each additional inch of ht

- **IBW ♀**
  = 100 lb (45.5 kg) for the first 5 ft (152 cm) of ht,  
  + 6 lb (2.7 kg) for each additional inch of ht

- Rule of Thumb: ♂ = Ht – 100; ♀ = Ht - 105

Protein Requirements

- Normal healthy individuals
  = 0.8 g /kg /day (~ 10 – 12 % of energy)

- Patients w/ acute illness
  = 1.2 – 1.5 g /kg /day (~ 15 – 25 % of energy)

- "24-hr UUN measurement" is the most practical method for estimating a patient’s protein catabolic rate

Protein Requirements (cont.)

- Protein balance (g/day)
  \[ \text{Protein balance (g/day)} = \text{Protein intake} - \text{Protein catabolic rate} \]

- Protein catabolic rate (g/day)
  \[ \text{Protein catabolic rate (g/day)} = [24\text{-hr UUN (g)} + 4] \times 6.25 \]
  - 6.25 g protein has 1 g of nitrogen
  - The value of 4 g added to the UUN represents an estimate of the unmeasured nitrogen lost in the urine, sweat, hair, skin, and feces
Example:

Pt A (BW 60 kg) is receiving BD (1:1) 1,500 Kcal/day, protein 72 g

Ix: 24-UUN = 12 g/day

His protein status is ..... 

\[
\text{PCR} = (12+4) \times 6.25 = 100 \text{ g/day}
\]

Negative protein status (- 28 g/day)

Order protein = 100 + 10 = 110 g/day
## Complications and The Selective Approach to Nutritional support

<table>
<thead>
<tr>
<th>Types of Pts</th>
<th>Complications</th>
<th>Feeding Approach</th>
</tr>
</thead>
</table>
| **Hypometabolic, Starved Pts** | **Refeeding syndrome** **• Hypophosphatemia**  
• Hypo Mg, Hypo K  
• Repletion cardiopulmonary failure | • Refeed gradually (start at 80% BEE), taking up to a week to reach the final calorie goal (2xBEE)  
• Normal K, Mg, P levels should be documented before repletion and monitored daily during the initial period of refeeding |
| **Hypermetabolic, Stressed Pts** | **Underfeeding**  
: Kwashiorkor  
**Overfeeding**  
: Hyperglycemia, abnormal LFTs, further increase cardiopulmonary workload | • Aggressive but not excessive nutritional support (reach energy and protein goal within 2-3 days)  
• REE levels 20-50% greater than calculated BEE  
• High protein catabolism |
Pathogenesis of Refeeding Syndrome

- Hypokalaemia
- Hypomagnesaemia
- Hypophosphataemia
- Thiamine deficiency
- Salt and water retention - oedema

Starvation / Malnutrition

Glycogenolysis, gluconeogenesis and protein catabolism

Protein, fat, mineral, electrolyte and vitamin depletion – salt and water intolerance

Refeeding (switch to anabolism)

Fluid, salt, nutrients (CHO major energy source)

↑ Glucose uptake
↑ Utilization of thiamine
↑ Uptake of K⁺, Mg²⁺ & PO₄²⁻

↑ Protein and glycogen synthesis

Insulin secretion
# Complications and The Selective Approach to Nutritional support

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<td></td>
<td>• Kwashiorkor</td>
<td>• REE levels 20-50% greater than calculated BEE</td>
</tr>
<tr>
<td></td>
<td>• Overfeeding</td>
<td>• High protein catabolism</td>
</tr>
<tr>
<td></td>
<td>• Hyperglycemia, abnormal LFTs, further increase</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cardiopulmonary workload</td>
<td></td>
</tr>
</tbody>
</table>
OUTLINE

- Nutritional Screening, Assessment, and Monitoring
- Malnutrition
  - Under-nutrition → PEM
  - Over-nutrition
- Nutritional support
  - General approach and complications
  - Enteral Nutrition (EN)
  - Parenteral Nutrition (PN)
- Conclusions
Enteral Formula Selection

**Major Criteria**

- Energy density
  - 1, 1.5, or 2 Kcal/ml
- Protein content
  - 15, 20, 25 % of total energy
- Route of administration
  - Oral vs tube
- Cost
Minor Criteria

- Complexity: Polymeric vs Oligomeric
- Osmolality
- Protein source
- Fat source: LCT vs MCT
- Fat content
- Residue content
- Electrolyte and mineral content
- Form: liquid vs powder; cans vs ready-to-hang
- Vitamin content
- Lactose content
<table>
<thead>
<tr>
<th>PRODUCT CATEGORY</th>
<th>PRODUCT</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kcal/ccL</td>
<td>HOUSE FORMULA (HIGH CALORIE/LOW RESIDUE)</td>
<td>1.5/1500</td>
<td>1.0/1000</td>
<td>1.5/1500</td>
<td>2/2000</td>
<td>1.2/1200</td>
<td>1.8/1800</td>
<td>1.8/1800</td>
</tr>
<tr>
<td>PRO (g/ccL)</td>
<td>.0625/62.7 (16.9%)</td>
<td>.0625/62.5 (20%)</td>
<td>.0625/62.3 (22%)</td>
<td>.0835/83.5 (16.9%)</td>
<td>.060/60 (20%)</td>
<td>.061/61 (18%)</td>
<td>.045/45 (18%)</td>
<td></td>
</tr>
<tr>
<td>CHO (g/ccL)</td>
<td>2036/203.6 (54.3%)</td>
<td>.133/133.3 (50%)</td>
<td>.133/133.1 (33%)</td>
<td>.2185/218.5 (42.2%)</td>
<td>.1145/114.5 (35%)</td>
<td>.1668/166.8 (34%)</td>
<td>.205/205 (42%)</td>
<td></td>
</tr>
<tr>
<td>FAT (g/ccL)</td>
<td>.049/49.1 (25%)</td>
<td>.0282/28.2 (25%)</td>
<td>.075/75 (45%)</td>
<td>.0905/90.5 (40.1%)</td>
<td>.0660/66 (45%)</td>
<td>.096/96 (40%)</td>
<td>.096/96 (40%)</td>
<td></td>
</tr>
<tr>
<td>Na (mg/ccL)</td>
<td>1.4/1400</td>
<td>1.3/1300</td>
<td>1.3/1300</td>
<td>1.45/1450</td>
<td>1.11/1110</td>
<td>1.06/1060</td>
<td>1.76/760</td>
<td></td>
</tr>
<tr>
<td>K (mg/ccL)</td>
<td>1.80/1800</td>
<td>2.10/200</td>
<td>2.52/2520</td>
<td>2.44/2440</td>
<td>2.02/2020</td>
<td>1.06/1060</td>
<td>1.12/1120</td>
<td></td>
</tr>
<tr>
<td>P (mg/ccL)</td>
<td>1.0/1000</td>
<td>1.20/1200</td>
<td>1.00/1000</td>
<td>1.05/1050</td>
<td>1.50/1500</td>
<td>1.50/1500</td>
<td>1.50/1500</td>
<td></td>
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<tr>
<td>Osmolarity</td>
<td>325</td>
<td>380</td>
<td>380</td>
<td>380</td>
<td>380</td>
<td>380</td>
<td>380</td>
<td></td>
</tr>
<tr>
<td>% Water</td>
<td>76.2%</td>
<td>83.1%</td>
<td>75%</td>
<td>70%</td>
<td>70%</td>
<td>72.5%</td>
<td>73.5%</td>
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</tr>
<tr>
<td>Volume To Meet 100% RDI</td>
<td>1000mL</td>
<td>1000mL</td>
<td>1000mL</td>
<td>948mL</td>
<td>1250mL</td>
<td>948mL</td>
<td>948mL</td>
<td></td>
</tr>
<tr>
<td>CHO Source</td>
<td>Corn Maltodextrin, Sucrose</td>
<td>Corn Maltodextrin, Sucrose</td>
<td>Corn Maltodextrin, Sucrose</td>
<td>Corn Maltodextrin, Sucrose</td>
<td>Corn Maltodextrin, Isomaltulose, Fructose</td>
<td>Corn Maltodextrin, Sucrose</td>
<td>Corn Maltodextrin, Sucrose</td>
<td></td>
</tr>
<tr>
<td>PRO Source</td>
<td>Sodium &amp; Calcium Caseinates, Soy Protein Isolate</td>
<td>Sodium &amp; Calcium Caseinates, Soy Protein Isolate</td>
<td>Sodium &amp; Calcium Caseinates, Soy Protein Isolate</td>
<td>Sodium &amp; Calcium Caseinates</td>
<td>Sodium &amp; Calcium Caseinates, Soy Protein Isolate</td>
<td>Sodium Caseinates, Soy Protein Isolate</td>
<td>Milk Protein Isolate, Sodium Caseinate</td>
<td></td>
</tr>
<tr>
<td>FAT Source</td>
<td>High Oleic Safflower Oil, Canola Oil, MCT</td>
<td>Soy Oil, MCT, Safflower Oil</td>
<td>High Oleic Safflower Oil, Canola Oil</td>
<td>High Oleic Safflower Oil, MCT, Canola Oil</td>
<td>High Oleic Safflower Oil, Canola Oil</td>
<td>High Oleic Safflower Oil, Canola Oil</td>
<td>High Oleic Safflower Oil, Canola Oil</td>
<td></td>
</tr>
<tr>
<td>Indications/Comments</td>
<td>Low residue formula for patients with increased caloric and protein needs or who have limited volume tolerance (237mL/can)</td>
<td>Very high-protein, fiber fortified (14.4 gm dietary fiber/L). For patients with wounds or who are at risk for PEM and/or pressure ulcers (237mL/can)</td>
<td>Calorically dense formula. For patients with type 1 or type 2 diabetes, hyperglycemia or impaired glucose tolerance resulting from metabolic stress, trauma, illness (237mL/can)</td>
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<td>Contains 17.0 gm dietary fiber. Including 10 g FOS. Indicated for patients with type 1 or type 2 diabetes and patients with impaired glucose tolerance (237mL/can)</td>
<td>Formula designed to help meet needs of altered metabolism of patient on dialysis (Stage 5 kidney disease). Low in Phosphorus, Calcium and Potassium. (237mL/can)</td>
<td>Indicated for patients with reduced kidney function. (237mL/can)</td>
<td></td>
</tr>
</tbody>
</table>
Fluid Requirement

- Rule of thumb: 30 – 35 mL/kg/day
- also depends on comorbid disease(s)
How to Calculate Free water in the Enteral formula?

- 1:1  ➔ 85% volume
- 1.2:1  ➔ 80% volume
- 1.5:1  ➔ 75% volume
- 2:1  ➔ 70% volume
Vitamin and Mineral Allowances

- The micronutrient needs of many ill patients are higher than those listed in the DRIs.
- Blood levels are generally the best measures available, but they do not always indicate sufficient levels in target tissues.
<table>
<thead>
<tr>
<th>PRODUCT CATEGORY</th>
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<th>C</th>
<th>D</th>
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<td>1.5/1500</td>
<td>2/2000</td>
<td>1.2/1200</td>
<td>1.8/1800</td>
<td>1.8/1800</td>
<td></td>
</tr>
<tr>
<td>HIGH CALORIE/ HIGH PROTEIN/GLYCEMIC CONTROL</td>
<td>0.027/62.7 (16.1%)</td>
<td>0.0625/62.5 (22%)</td>
<td>0.065/82.5 (22%)</td>
<td>0.085/63.5 (22%)</td>
<td>0.66/60 (16%)</td>
<td>0.661/61 (18%)</td>
<td>0.45/45 (14%)</td>
<td></td>
</tr>
<tr>
<td>HIGH CALORIE (2 Kcal/mL)</td>
<td>2.036/203.6 (54.3%)</td>
<td>1.383/138.3 (50%)</td>
<td>1.331/133.1 (33%)</td>
<td>2.185/218.5 (45%)</td>
<td>1.145/14.5 (35%)</td>
<td>1.166/16.6 (34%)</td>
<td>2.05/25 (42%)</td>
<td></td>
</tr>
<tr>
<td>LOW PROTEIN/ LOW ELECTROLYTE (PRE-DIALYSIS)</td>
<td>0.0491/49.1 (29%)</td>
<td>0.0282/28.2 (25%)</td>
<td>0.075/75 (45%)</td>
<td>0.0905/90.5 (40.1%)</td>
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<td></td>
</tr>
<tr>
<td>K mg/cc/mL</td>
<td>1.800/1800</td>
<td>2.100/2100</td>
<td>2.520/2520</td>
<td>2.440/2440</td>
<td>2.020/2020</td>
<td>1.060/1060</td>
<td>1.120/1120</td>
<td></td>
</tr>
<tr>
<td>P mg/cc/mL</td>
<td>1.2/1200</td>
<td>1.200/1200</td>
<td>1.000/1000</td>
<td>1.050/1050</td>
<td>800/800</td>
<td>700/700</td>
<td>700/700</td>
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<tr>
<td>Osmolality</td>
<td>525</td>
<td>380</td>
<td>875</td>
<td>725</td>
<td>720</td>
<td>585</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>% Water</td>
<td>76.2%</td>
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<td>Sodium &amp; Calcium Caseinates</td>
<td>Sodium &amp; Calcium Caseinates</td>
<td>Caseinates (Ca, Mg &amp; Na), Milk Protein Isolate</td>
<td>Milk Protein Isolate, Sodium Caseinate</td>
<td></td>
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<tr>
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<td>Soy Oil, MCT, Safflower Oil</td>
<td>High Oleic Safflower Oil, Canola Oil</td>
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</tr>
</tbody>
</table>
Enteral Infusion Methods

- **Bolus method**
  - Long-term feeding in stable patients
  - More mobility
  - Reduces cost

- **Intermittent method**

- **Continuous-drip method**
  - Via a feeding pump
  - More reliable nutrient delivery
  - May reduce the risks of gastric distension and pulmonary aspiration
Common problems in tube-fed pts

- Pulmonary aspiration
- Diarrhea
- Gastric retention
- Metabolic complications
Common problems in tube-fed pts

- Pulmonary aspiration
- Diarrhea
- Gastric retention
- Metabolic complications
Preventive Measures to Reduce Aspiration Risk

- Head elevation 30°
- Post-pyrolic feeding
- Switch to continuous infusion
- Agents to promote motility, such as prokinetic drugs (metoclopramide and erythromycin)
Common problems in tube-fed pts

- Pulmonary aspiration
- Diarrhea
- Gastric retention
- Metabolic complications
Likely Causes of Diarrhea in Tube-Fed Patients

- **Medications**
  - Elixir medications: sorbitol
  - Mg-containing antacids
  - Antibiotics
  - Phosphorus supplements
  - Others: H₂ receptor blockers, metoclopramide, lactulose

- **Pseudomembranous colitis (PMC)**
  - Clostridium difficile

- **GI Disorders**
Common problems in tube-fed pts

- Pulmonary aspiration
- Diarrhea
- **Gastric retention**
- Metabolic complications
Most common causes of Gastric Retention:

- Bowel ileus
- Hypokalemia
- Drug side-effects
- Gut obstruction
Common problems in tube-fed pts

- Pulmonary aspiration
- Diarrhea
- Gastric retention
- Metabolic complications
Metabolic complications of Enteral Feeding

- Far fewer than PN
- Hyperglycemia – most common
- Dehydration → constipation
OUTLINE

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Methods of Administration

- Central (CPN)
- Peripheral (PPN)

Admixtures:
- 2-in-1
- 3-in-1
Macronutrients

- **Dextrose Monohydrate**
  - 3.4 Kcal/ g
  - Concentration : 2.5 – 70 %

- **Lipid Emulsions**
  - soybean oil, safflower oil, MCT/LCT, olive oil, fish oil
  - 10 % → 1.1 Kcal/ ml
  - 20 % → 2.0 Kcal/ ml

- **Amino Acids**
  - Crystalline amino acids concentration : 3.5 – 20 %
  - 4 Kcal/g : should be counted as part of the energy intake
  - Formulas enriched w/ BCAA : Hepatic encephalopathy

Micronutrients

- The U.S. RDI for micronutrients do not apply to PN because TPN bypasses the absorptive process
## Requirements for Maintenance Parenteral Vitamin Intakes

For maintaining already normal circulating vitamin levels

<table>
<thead>
<tr>
<th>Vitamins</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>3300 IU (990 μg)</td>
</tr>
<tr>
<td>Thiamin (Vitamin B1)</td>
<td>6 mg</td>
</tr>
<tr>
<td>Riboflavin (Vitamin B2)</td>
<td>3.6 mg</td>
</tr>
<tr>
<td>Niacin (Vitamin B3)</td>
<td>40 mg</td>
</tr>
<tr>
<td>Pyridoxine (Vitamin B6)</td>
<td>6 mg</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>15 mg</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>5 μg</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>200 mg</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>200 IU (5 μg)</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>10 mg (10 IU)</td>
</tr>
<tr>
<td>Folic acid</td>
<td>600 μg</td>
</tr>
<tr>
<td>Biotin</td>
<td>60 μg</td>
</tr>
<tr>
<td>Phylloquinone (Vitamin K)</td>
<td>150 μg</td>
</tr>
</tbody>
</table>

JPEN, 2003;17: 220.
**Mineral provided and Daily Mineral allowances in TPN**

<table>
<thead>
<tr>
<th>Cations</th>
<th>Associated Anions</th>
<th>Daily Mineral Allowances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>acetate, chloride, phosphate, bicarbonate</td>
<td>1-2 mEq</td>
</tr>
<tr>
<td>Potassium</td>
<td>acetate, chloride, phosphate</td>
<td>1 mEq</td>
</tr>
<tr>
<td>Calcium</td>
<td>gluconate, gluceptate, chloride</td>
<td>10 - 15 mEq</td>
</tr>
<tr>
<td>Magnesium</td>
<td>sulfate</td>
<td>16 – 24 mEq</td>
</tr>
<tr>
<td></td>
<td>Phosphate (provided in the sodium or potassium salt form)</td>
<td>20 - 40 mmol</td>
</tr>
</tbody>
</table>
Calcium, magnesium, and phosphorus

** The co-solubility of admixtures of calcium, magnesium, and phosphorus

- is limited
- varies according to the amino acid preparation used (particularly its pH)
- Self limits of compatible electrolyte concentrations per 1000 ml final volume, in addition to the phosphorus present in the amino acid base solution, are:

<table>
<thead>
<tr>
<th>Formula</th>
<th>Central vein</th>
<th>Peripheral vein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium (mEq)</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Magnesium (mEq)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Phosphorus (mmol)</td>
<td>15</td>
<td>10</td>
</tr>
</tbody>
</table>
Cycling the TPN

- Day 1: 20-hour cycle
- Day 2: 16-hour cycle
- Day 3: 12-hour cycle

In all cases, infuse at 50 ml/hr during the final hour.
Management of TPN

- Inserting the central catheter:
  - Subclavian, internal jugular, PICC
  - Hickman, port

- Ordering solutions

- Terminating the infusion:
  - Taper the infusion rate by 50-70% for 30-60 minutes before termination

- Follow-up labs:

<table>
<thead>
<tr>
<th>Measure daily until stable, then 2-3 times weekly</th>
</tr>
</thead>
<tbody>
<tr>
<td>: Electrolytes (Na, K, Cl, HCO₃), glucose, phosphorus</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measure 1-2 times weekly</th>
</tr>
</thead>
<tbody>
<tr>
<td>: Ca, Mg, LFTs, BUN, Cr, triglyceride, serum prealbumin</td>
</tr>
</tbody>
</table>
Complications of PN

- **Technical complications**
  - Pneumothorax, hemothorax
  - Malposition of catheter
  - Artery puncture
  - Air embolism
  - Thrombosis

- **Septic complications**
  - Catheter-related sepsis
  - Septic thrombosis

- **Metabolic complications**
  - Hyperglycemia
  - Hyper- / Hypo : K, Na, Ca, P
  - Abnormal LFTs
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Algorithm for Implementation of Nutritional Support

Does the pt have or at risk of PCM?

Would NS improve the prognosis or QOL?

• Energy, macro-/micronutrient, and fluid needs = ?
• Can these be provided enterally?

Are Oral foods+liquid supplements enough?

TPN?

• Close observation
• Calorie count

Feeding tubes
• Wks → nasal tubes
• Months or yrs → percut. tubes

• Risks and discomfort outweigh potential benefits
• General comfort measures

Request CVC, PICC or peripheral cath + EN

Request CVC, or PICC
• Wks → Subclavian catheter or PICC
• Months or years → Tunneled external catheter or SC infusion port
Conclusions

- Malnutrition
  - Increases risk of complications
  - Reduces effectiveness of medical treatment
  - Lengthens hospital stay
  - Increases mortality

- Nutritional status indicators should be thought of as vital signs

- Nutritional support should be a routine and integral part of medical care, but still not the primary treatment
References and Further Reading:

- Krause’s Food and Nutrition Therapy, 12th ed, 2008.